THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

AUGUST, 1888.

Thou Lord in the beginning hast laid the foundation of the earth and the heavens are the works of thy hands.

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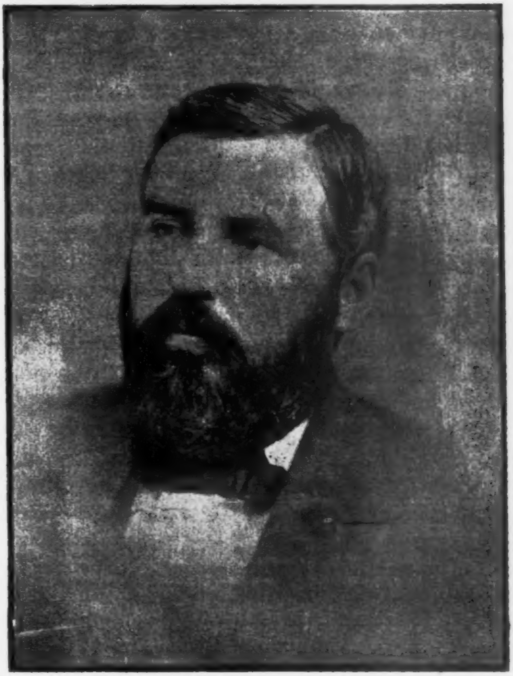


BIOGRAPHICAL MEMOIR OF JAMES CRAIG WATSON.*

PROFESSOR GEORGE C. COMSTOCK.†

At some unknown time, prior to the war of Revolution, the ancestors of James Craig Watson emigrated from Ireland to the colony of Pennsylvania. We know little of the fortunes

* Read before the National Academy, April, 1888.
† Director of Washburn Observatory, Madison, Wisconsin.

of this family before the early years of the present century, but they must, at that time, have been at a low ebb, for, in 1811, we find James Watson, the grandfather of the future astronomer, abandoning the land of his birth and pushing westward seven hundred miles to build for himself a new home in the almost unbroken forests of Upper Canada. The journey was made on foot. William, the father of James Craig Watson, then an infant of tender years, was placed upon an ox-sled which, slipping easily over the fallen leaves, bore the scanty household goods of the family.

They reached their destination in safety, and the work of clearing and cultivating was begun, but the times were unpropitious. Before the year had passed war was declared between the United States and Great Britain, and, Canada becoming the scene of hostilities, James Watson was compelled to abandon his farm for a time and to fly to the East for safety. Upon the return of peace he again took up his former residence, prospered in his labors, and was, at the time of his death, a man of wealth and consequence in the community which had grown up about him But this man's life was not devoted wholly to clearing up his homestead and increasing his acres; he possessed a taste for books and for learning, for the gratification of which he collected an excellent library whose appreciation and use he taught to his children.

Amid these surroundings William Watson grew to manhood, acquiring his father's tastes and learning, but not his energy and practical ability. At the age of twenty-six he married Rebecca Bacon, a native of Nova Scotia. Four children were the fruit of this union, of whom the oldest, James Craig Watson, was born near the villiage of Fingal, county of Elgin, Canada West, on January 28, 1838. The boy inherited a genial disposition and the taste for study which we have noted in his father and grandfather, but the restless and tireless activity which was displayed throughout his whole life, was clearly derived from his mother.

The first twelve years of his life were spent upon the farm in Canada, his father pursuing by turns the occupations of farmer, carpenter and schoolmaster, and instructing his children, three sons and a daughter, in that measure of book lore which he himself had acquired. But affairs went

ill with William Watson, and, in 1850, he found himself compelled to abandon his home and seek elsewhere a livelihood for himself and family. He turned westward, not knowing where his foot should find a resting place, but resolved to leave Canada. Arriving in Detroit, Mich., the family found its choice of a home limited to the villages along the single line of railway that then extended west a scanty hundred miles from Detroit. A chance remark made by a stranger, that the State University was situated at Ann Arbor on this line of railway, only forty miles distant, determined the choice. A vague idea that perhaps her children might derive some educational advantages from it seems to have been in the mind of Rebecca Watson, and the decision was made by her.

The family reached Ann Arbor penniless and more destitute than that ancestor who, forty years before, had emigrated to the frontier of Canada. The father found work in a small factory, and James, now a bright boy of twelve years, was employed in various menial offices at the same place. The following years were years of bitter poverty and want, and they left their imprint deep upon the after life of James Watson; but they were also years of development. He quickly learned the work of the factory and noted the incompetence and faithlessness of the man in charge of the steam engine, which he reported to his employer. "I know, Jimmy, the man ain't worth his salt, but he is the only one I can get for the job." "I can run the engine, sir," was the reply. "Oh, no, Jimmy, you don't know how to manage an engine." "But I do;" and the dispute was settled by going to the engine room, where Jimmy satisfied his employer that he did understand the engine. The incompetent man was forthwith discharged and the boy of thirteen became engineer of the factory.

Here he had some chance for study, and a Latin or Greek text-book was kept in a convenient corner and brought out for use whenever a few minutes could be spared from work. In the following winter the factroy was closed and Watson was reduced to the necessity of peddling apples and books at the railway station, an occupation which was exceedingly distasteful to him. As spring approached he disappeared, and for a fortnight nothing was heard from him,

until his former employer, who had become much interested in the boy, found him in Detroit, where he had made a bargain with the master of a vessel to go sailing with him in the lake trade, and was to have started on the following day. He was induced to return home, and soon after it was resolved that he should attend school, but at the end of the first half day the relations of teacher and pupil were interchanged; the boy withdrew from school, and the master came to him for instruction in algebra and geometry.

During the next two years Watson's employment was of a desultory character. There were vague hopes that he might at some time enter the University, and he therefore pursued by himself the study of Latin and Greek; but he also worked successively at nearly all the trades that were practiced in the village, becoming a competent workman at most of them, and acquired special skill as a machinist. It was noticeable that during this period he avoided association with boys of his own age and sought the companionship of men, with whom he would discuss topics of current interest, entertaining them with jests and with exhibitions of expert penmanship or of skill in arithmetical operations.

At the age of fifteen Watson entered the University of Michigan as a student, and soon attracted attention for the excellence of his scholarship in every direction. For the classical languages he displayed unusual capacity, and his now venerable instructor, Dr. Frieze, bears witness that "his facility in translation was greater than that of most professors of Latin and Greek;" and the writer of this sketch well remembers the enthusiasm with which he was wont in his later years to refer to his study of the ancient tongues.

The man who, during Watson's university career, exercised the greatest influence over his development was, probably, Francis Brünnow, who had been recently called to the chair of astronomy and the directorship of the new observatory. Brünnow introduced into a Western college the methods of a German university, and lectured in broken English to despairing and dwindling classes until Watson remained his only pupil. He became interested in astronomy early in his college course, and in his junior year began work in the observatory. The theoretical and practical sides of the science

seemed to have equal charms for him, and his attention was divided between the *Mecanique Celeste* and the construction a refracting telescope. His mechanical talent and the training of the machine shop triumphed over the difficulties of the latter and produced an excellent instrument of four inches aperture, the grinding and polishing of the glass and the constructing of the mounting being all done by his own hands. Nor was his work of a purely empirical character. There exists now, in Watson's hand writing, a long manuscript translation from *Prechtl's Dioptrik* upon the theory and construction of achromatic objectives, and bearing at its close the signature and date, James C. Watson, January 8, 1857. He was then nineteen years of age.

Watson graduated in 1857 and almost immediately thereafter commenced work in the observatory as a salaried assistant. His earliest contribution to a scientific periodical which I have been able to find appears in Vol. V. of Gould's *Astronomical Journal* and bears the date of April 20, 1857. His great activity at this time is shown by the index to this same volume, which contains under his name the titles of no less than fifteen papers, all published before he had completed his twentieth year.

In 1859 Brünnow resigned his chair in the University of Michigan to assume the directorship of the Dudley Observatory, and Watson was elected Professor of Astronomy and took charge of the observatory, but without the title of director. In 1860 Brünnow returned to Ann Arbor and was re-elected to his former position, Watson being transferred to the chair of physics, which he held until 1863, when, Brünnow again resigning, he was chosen to be Professor of Astronomy and Director of the Observatory. The records of the board of regents of the university show that this appointment was made upon the recommendations of B. A. Gould, Elias Loomis, William Chauvenet, Benjamin Peirce, Joseph Winlock, J. M. Gilliss, and others. In the manly communication to the governing board of the university, in which Watson presents his application for appointment to the directorship and sets forth his qualifications for the position, he states that, in addition to the discharge of the duties which his instructorship in the university entailed upon him, he had prepared and published thirty-two orig-

inal papers upon astronomical subjects. An examination of his contributions to the periodicals shows that this activity was mainly expended in work upon comets and the minor planets. There are numerous communications containing observations and computations of orbits and ephemerides, and an occasional paper of a theoretical character upon the determination of orbits. To this period of his life belongs his "Treatise on Comets," a work of a popular character, to whose preparation he was incited by the interest aroused by the great comet of 1858.

In May, 1860, he married Annette Waite, of Dexter, Michigan, who, during the remaining twenty years of his life, maintained a constant interest and partial co-operation in his scientific work. No children were born to them.

Early in the '60's Watson became interested in the reduction of the Washington Zones, which had been undertaken by Dr. Gould, and for several years a considerable part of his time was given to computation upon this work. As a computer he possessed extraordinary skill and rapidity, attested at a later period by the computation of elliptic elements of a planet's orbit at a single sitting. The possession of this skill perhaps acted injuriously upon the character of his scientific work, as it led him to give much of his time, as a paid computer, to work which others of inferior talent could have done equally well, though less rapidly.

Immediately after his appointment to the directorship of the observatory Watson begun the preparation of a series of charts of stars lying near the ecliptic, and his reports upon the work of the observatory during the following ten years represent this as being his principal employment, and dwell upon its laborious character. But scant traces of this work can now be found in the records of the Ann Arbor Observatory. The charts which he prepared have become the property of the National Academy of Sciences and are deposited at the Washburn Observatory of the University of Wisconsin. Of these charts, nineteen in number, only two are finished. They are in their general plan similar to Peters's well known charts, but are far from being equally complete. The discovery of the minor planets, with which Watson's name is associated, was a direct consequence of this work; indeed the expectation of such discoveries was

probably the incentive to it. His first planet, Eurynome (79), was found in 1863, only three weeks after his election to the directorship of the observatory. Four years elasped before another was found, but during the ensuing years they came in rapid succession. In all, twenty-two of these bodies were discovered by him, the year 1868 alone contributing six to the list, at that time an unprecedented feat. The Lalande prize, decreed to him July 11th, 1870, by the *Academie des Sciences*, was the reward of his earlier labors in this field.

The composition of his treatise upon *Theoretical Astronomy* belongs to the earlier years of his directorship and stands in close relation with his work as a computer and observer of the minor planets. The completion of this treatise, which appeared when he was but thirty years of age, left Watson's hands free for other work, and in 1869 he became associated with Benjamin Peirce in work upon the improvement of the lunar tables. For five years he was engaged in a comparison of the theories of Hansen and Peirce with observation, and spent much time in the endeavor to simplify Hansen's tables, with results which, though satisfactory to himself, were never published and are now lost.

The eclipse expeditions to Iowa in 1869 and to Sicily in 1870 interrupted the continuity of his work, and in 1874, when he accepted charge of the transit of Venus party to China, it was dropped, never to be resumed. The charge of this expedition was Watson's most important scientific commission. In a letter written to Benjamin Peirce, in 1873, he had, in opposition to LeVerrier's well-known views, expressed the opinion that the transit of Venus should be observed by astronomers as extensively as possible, and that every device known to science should be brought to bear upon these observations for the determination of the solar parallax. It is interesting now to note that in this letter he expresses the opinion that observations of contacts and measurements with the heliometer will be found to give a much more trustworthy determination of the parallax than can be obtained by the photographic method, but he joins to this the statement that the photographic method ought to be thoroughly tested.

Watson undertook the conduct of the expedition to China

deeply impressed with the responsibility which it imposed upon him, and the last six months of 1874 were among the most laborious and oppressive of his life. It was, therefore, with a sense of profound relief that he saw this period of arduous labor crowned with the success of his party in the observation of the transit at Peking. It is interesting to note that on October 10, 1874, at Peking, he discovered the minor planet Juewa (139). The return from China was made leisurely *via* India, Egypt, and Europe, several weeks being spent in Egypt, at the invitation of the Khedive, in instruction and co-operation with the engineer officers of the Egyptian army in the first steps toward a geodetic survey of that country. This work, performed by Watson without pecuniary compensation, won for him the cordial thanks of the Khedive and the decoration of Knight Commander of the Imperial Order of the Medjidich of Turkey and Egypt.

Close following upon Watson's return to America came his appointment as one of the judges at the International Centennial Exposition of 1876, in connection with which he prepared an elaborate report upon the horological instruments there exhibited.

The year 1878 brought a new subject, which engaged much of Watson's attention during the few remaining years of his life. He had corresponded with LeVerrier about the supposed planet Vulcan, and believed firmly in its existence, and, at LeVerrier's request, had co-operated with him in securing observations of the sun's disk at the times of expected transits of the planet. The eclipse of 1878 offered a favorable opportunity of search for this body, of which he eagerly availed himself, and mounted his telescope upon the crest of the Rocky Mountains at Separation, in Wyoming Territory. We need not here recount the details of the observations which led to the announcement of the discovery of two new bodies supposed to be intra-mercurial planets, since Watson has himself given an account of these in the *American Journal of Science* and in the *Astronomische Nachrichten*. Suffice it to say that he returned home firm in the conviction that he had discovered the unknown Vulcan and, perhaps, another planet as well. Uncertainty as to the latter object soon gave away to confidence that both the

bodies seen by him must be major planets moving within the orbit of Mercury. The scientific world was skeptical, but he would convince it that its lack of faith was unwarranted.

The directorship of the new observatory founded at Madison, Wisconsin, by the liberality of ex-Governor Washburn had before this been offered him, but he had hesitated, unwilling to leave the surroundings in which the greater part of his life had been passed. But the scale was now turned, and the promised superior equipment of the new observatory carried him to a new home, confident of speedily demonstrating the reality of his discoveries.

He removed to Madison and entered upon the directorship of the Washburn Observatory in the spring of 1879. The observatory was then far from complete; its large equatorial was mounted, but was its only instrument, and Watson's energies were spent, even to the last hours of his life, in designing and superintending the construction of new buildings and new apparatus. In the midst of this activity time was found for a return to the problem of telescope-building, which had occupied his student days. Optical glass was procured and plans laid for the construction, under his personal supervision, of several objectives which were to embody his own ideas upon this art, and work was actually commenced upon one large reflecting telescope. But no stress of other work or other interests could displace Vulcan from his mind. A scheme was devised whereby he should be able to observe the planet at noon-day without the intervention of an eclipse. The hill upon which the observatory stands slopes sharply to the south. At the foot of this hill was dug a deep cellar with a tube extending from it through the soil, parallel to the earth's axis and terminating in a masonry pier at the top of the hill. A telescope was to be so mounted in the celler as to point up through the tube to a heliostat mounted at its upper end, by which rays of light coming from the sun or other celestial body might be directed into the telescope. The tube, fifty-six feet in length, was to serve as a long dew-cap and enable the observer to sweep close up to the sun's limb without being blinded by the stray light surrounding it. So confident was Watson of the success of this device, and that by its aid

Vulcan could be refound, that he did not hesitate to undertake its construction at an expense to himself of several thousand dollars.

He did not live to see its completion, nor the fruition of any of the plans which he had formed for the observatory. Signs, more easily recognized after his death than at the time of their occurrence, pointed to a diminishing vitality and to a weakening of his physical powers. There was, however, no diminution of an activity which exposed him daily to the inclemencies of an approaching winter, and his rotund figure and ruddy face seemed to give little cause for apprehension. Stricken down by a congestive chill, from which he partially rallied and then relapsed, he died November 22, 1880, within forty-eight hours after the suspension of his ordinary daily work.

Watson's scientific work was far from being the measure of his life, and any estimate of his career which did not take into account other sides of his character would be far indeed from the mark. The stern experiences of his boyhood had stunted the growth of qualities which a more genial lot might have developed in him, and in estimating his character as a man this early training must not be overlooked. It had taught him the value of money, and he eagerly sought its acquisition as a source of power. He engaged in business enterprises, and became an insurance agent, a photographer, a bookseller, a printer and publisher, and an insurance actuary, with moderate pecuniary success, but with the result of acquiring a peculiar power and influence over men of affairs, which he used to the marked advantage of the educational and scientific institutions with which he was connected.

The subject of life insurance early attracted his attention and interest, and for nearly half his life he was engaged in its practical workings. I cannot do better than quote in this connection the words of one of his colleagues in the University of Michigan, Hon. Thomas M. Cooly, long upon the supreme bench of that state. "Few knew so well as I did the valuable services he rendered to the people in placing the great interest of life insurance upon a solid foundation. He understood thoroughly the principles of this business and was impatient that irresponsible organizations, by decep-

tion and fraudulent contrivances, should draw money from the people under the false pretense of insuring their families against loss by death. He thought, too, that there should be home organizations, whereby the vast and steady flow of money from the state should be stopped, and the accruing profits from insurance retained and expended among our own people. When, at last, such an organization was perfected he was invited, quite unexpectedly to himself, to be its actuary, and so invaluable have his services been found that his judgment has come to be accepted as law by the able business men who have been at the head of its affairs. * * * Some of us had personal knowledge that more than one state legislature invited his assistance in framing insurance laws, and that he had large influence in preventing crude and mischievous legislation on a subject with which the general public is unfamiliar, and concerning which those who think they know it well are generally the most profoundly ignorant."

There lies before the writer of this sketch a letter from the secretary of the company whose actuary Watson was, confirming this estimate of his services and attributing the success of the company largely to his influence. Watson's long connection with insurance matters led, in his later years, to the preparation and publication of extensive tables—his Interest and Investment Tables—for facilitating commercial and financial computations.

As a college professor Watson had great popularity among his students, but it was not a popularity of the best kind. His class-room work was conducted upon the avowed theory that his duty was to help those who sought a knowledge of astronomy and not to coerce into study the indifferent and careless. The latter class flocked in great numbers to his lectures and were delighted with the fluency and easy grace which imparted a charm to his discourse, and which carried them over the allotted ground with little expenditure of time or thought. Watson's instruction was mainly given by lectures, and the felicity of his discourse cannot be better illustrated than by a scene which will not readily pass from the memory of those who witnessed it. He had been summoned as an expert witness in an action to recover the insurance on a building destroyed by a tornado, and was to tes-

tify in regard to the laws of storms. The examination began in the usual dry and formal manner, by direct question and answer, but the questions grew fewer and the answers longer until, their surroundings forgotten, judge and jury, attorneys and spectators, sat listening to a popular exposition of the science of meteorology, going far outside the scope of the case at bar.

Watson was singularly indifferent to the opinions of the community in which he lived—an indifference rendered the more remarkable by the fact that he took a lively interest in local affairs and local controversies. He had bitter enemies and they circulated reports, to the discredit of his personal character, which went uncontradicted and gained undeserved credence. It cannot be denied that a measure of truth attended many of these statements, but they were habitually distorted and magnified out of all proportion. He wished his life and character to be estimated by the world at large. His scientific reputation he valued more highly than local esteem. "Let that be established," he was wont to say, "and opinion here will fall in with it"—a view partly, but not entirely, justified by the event. Within the circle of his own family he was a generous man, and in his college relations his pre-eminent abilities were freely placed at the service of such of his colleagues as needed them. For the ordinary forms of social intercourse he had no taste, and held himself aloof from them, giving to his work hours that others spent in recreation, thus crowding more of achievment into the years of his life, but in the judgment of his friends, lessening their number.

Watson was elected a member of the National Academy of Sciences in 1868, and by his will the National Academy was made the residuary legatee of his estate, which is "to be aggregated, kept, and invested as a perpetual fund, the income fiom which shall be expended by said academy for the promotion of astronomical science." The academy has accepted this trust, and administers it in accordance with the following provisions of the will:

"In order to carry out the wish hereinbefore expressed as to the disposal of the income from the fund resulting from my estate hereby devised to said National Academy of Sciences, I do hereby direct that the designation of the particular objects and works which may be aided by this fund shall be de-

termined, subject to approval by a vote of the academy, by a board of trustees, three in number, who shall be members of the academy, and elected after the first herein named by said academy whenever a vacancy may occur, by death or otherwise. The trustees so appointed shall hold said office unless voluntarily relinquished by them during the period of their membership in the said National Academy of Sciences, and I do hereby appoint and constitute *Julius E. Hilgard*, of the United States Coast Survey, and *Simon Newcomb* and *J. H. C. Coffin*, professors of mathematics, U. S. Navy, all of Washington, in the District of Columbia, to be the first board of trustees for the purposes herein named.

"It is my wish that the academy may, if it shall seem proper, provide for a gold medal of the value of one hundred dollars, to be awarded, with a further gratuity of one hundred dollars, from time to time, to the person in any country who shall make any astronomical discovery or produce any astronomical work worthy of special reward as contributing to our science. It is my further wish that provision be made for preparing and publishing tables of the motion of all the planets which have been discovered by me as soon as it may be practicable to do so; and I desire that in all cases the trustees and the academy shall act in harmony to obtain results of greatest possible aid to our science from the income fund resulting from my estate. I desire that results so obtained shall be published as speedily as possible in such manner as may be provided by the academy."

The amount of the fund, principal and accrued interest, was, in April, 1886, a little less than $15,000. The medal provided by the will was awarded but once. At the April, 1886, meeting of the National Academy it was, at the recommendation of the board of trustees of the Watson fund, "*Resolved*, That the Watson medal and the further sum of $100 in gold be awarded to Dr. Benjamin Apthorp Gould for his valuable labors for nearly forty years in promoting the progress in astronomical science, and especially for his successful establishment of the National Observatory of the Argentine Republic, as manifested in the six volumes of observations recently prepared and published by him."

I close this brief sketch of Watson's life with a list of his more important published works, omitting the numerous observations, ephemerides, and notices of the discovery of minor planets which are contained in the astronomical periodicals. In lieu of the latter there is appended a list of twenty-two planets discovered by him, together with the dates of their discovery.

A List of the more important Public Writings of James C. Watson.

On the Extraction of Roots: *Michigan School Journal* (1859).
On the Orbit of Pandora (55): *Brunnow's Astron. Not.*, vol. i., p. 59.

On the Orbit of Hestia (46): *Brunnow's Astron. Not.*, vol. i., p. 121.
A Popular Treatise on Comets: *Philadelphia*, 1861.
Correction of the Elements of the Orbit of a Comet: *Am. Jour. Sci.*, 1863, p. 218.
Investigation of the Orbit of Eurynome (79): *Astr. Nachr.* vol. lxiv., col. 23.
Theoretical Astronomy relating to the Motions of the Heavenly Bodies around the Sun in accordance with the Law of Universal Gravitation: *Philadelphia*, 1868.
Horological Instruments. United States International Exhibition, 1876. Reports and Awards. Group xxv., p. 56: *Washington*, 1880.
Discovery of an Intra-Mercurial Planet: *Astr. Nachr.*, vol xciii., col. 141, 161, 189, 239; vol. xcv., 102; *Am. Jour. Sci.*, vol. xvi., pp. 230, 310.
Watson's Interest and Investment Tables: *Ann Arbor*, 1879.

List of Minor Planets discovered by James Watson.

No.	Name.	Date of Discovery.	No.	Name.	Date of Discovery.
79	Eurynome..	1863, Sept. 14	121	Hermione	1872, May 12
93	Minerva.....	1867, Aug. 24	128	Nemesis	1872, Nov. 25
94	Aurora.......	1867, Sept. 6	132	Æthra	1873, June 13
100	Hekate.......	1868, July 11	133	Cyrene	1873, Aug. 16
101	Helena	1868, Aug. 15	139	Juewa	1874, Oct. 10
103	Hera	1868, Sept. 7	150	Nuwa	1875, Oct. 18
104	Klymene	1868, Sept. 13	161	Athor	1876, April 16
105	Artemis......	1868, Sept. 16	168	Sibylla.............	1876, Sept. 28
106	Dione	1868, Oct. 10	174	Phædra	1877, Sept. 2
115	Thyra	1871, Aug. 6	175	Andromache.....	1877, Oct. 1
119	Althæa.......	1872, April 3	179	Klytæmnestra..	1877, Nov. 11

THE ANNUAL MOTION OF THE EARTH.

PROFESSOR JOHN HAYWOOD.*

For THE SIDEREAL MESSENGER.

To assist elementary pupils in geography and astronomy we make use of the artificial globes, terrestrial and celestial, and find them indispensable. By the aid of these the pupil acquires correct ideas of the form of the earth and its diurnal motion. Then, with sufficient thought and attention to the phenomena of day and night, of the rising and setting of the sun, moon and stars, he is able to place his knowledge, and can assure himself of the reality of the knowledge he has been acquiring.

So, by the aid of the orrery and the like apparatus, a gen-

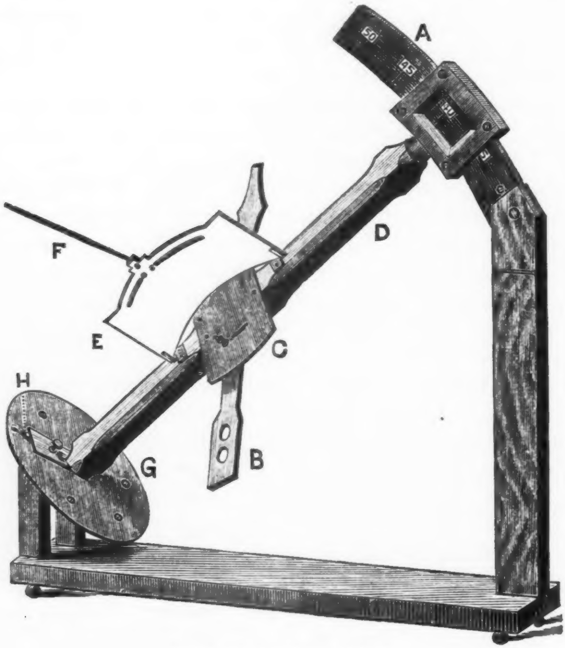
* Otterbein University, Westerville, Ohio.

eral idea of the situation of the earth in the solar system is acquired, and its relation to the sun and other planets. But it is not so easy to place the facts as they are learned and recognize them as he looks out upon the heavens. The difficulty springs from the fact that we must study the orbital motion from one position on the earth; and, therefore, we must distinguish between the effects of the diurnal rotation and the annual motion. The astronomer readily learns to overcome this difficulty for himself. But the teacher wants something that shall assist him to present the annual motion, with the readiness, the certainty, the completeness, with which the globe presents the form and diurnal motion.

It will be readily seen that one reason why the diurnal motion is more readily comprehended by the pupil is that the horizon does not change its position with respect to the axis of the earth; and the proposition that the earth turns on its axis towards the east, he soon is able to verify by his own observations. On the other hand, the horizon is continually changing its position in relation to the direction of the earth's motion in its orbit. This direction coincides with the tangent to the orbit. What is wanted, therefore, is an instrument which will readily and certainly show the tangent in its true position, whatever be the true position of the horizon. This is accomplished in the tangent index by combining a movement like that of the equatorial telescope about the terrestrial axis with a system of geocentric coördinates peculiar to the tangent. These are, first, the inclination of the tangent to the plane of the equator. This is the tangent declination. Second, the diedral contained between the planes of the two hour circles, viz., the hour circle of the sun, and the hour circle which contains the tangent. This diedral I have heretofore named the tangent hour angle. But Professor Young has expressed his disapproval of this use of the term, hour angle, as leading to confusion in its more legitimate use. Therefore, in deference to him, I now suggest the name, sun-tangent-equatorial angle, or, more shortly, sun-tangent angle. These two coördinates are computed and tabulated for use. There is also what may be called a local coördinate, the solar hour angle, or the true solar time of day, which, of course is to be taken from the ordinary clock or watch. The mathematical analysis of the index

with its formulas is omitted here; as this was given in full with the tables in the SIDEREAL MESSENGER for November 1886.

The cut represents the tangent index, and one can easily from it obtain a pretty good idea of the manner of using it.



THE TANGENT INDEX.

A, Latitude arc. B, Tangent index. C, Tangent declination arc. D, Axis of the earth. E, Solar declination arc. F, Radius vector. G, Time circle. H, Time index and solar tangent equatorial arc.

The instrument is to be placed upon a horizontal table, and in the meridian, with the elevated end to the north. The north end of the axis is to be placed at an angle of elevation equal to the latitude of the place. This places the axis parallel to the earth's axis. The two axis may be considered coincident, with the center of the instrument at the center of the earth. Set the tangent at the declination for the date, also set the sun tangent angle for the date. Then turn the

instrument on its axis until the time index points to the true solar time of day. The tangent index is now coincident with the tangent to the earth's orbit, and it points in the direction of the earth's motion in space. Also by keeping the time index in place by moving forward to the proper time, the index will continue to point in the same direction in space. Thus by this instrument we eliminate the perplexing diurnal motion and exhibit the direction of the annual motion pure and simple.

THE TANGENT INDEX TABLE FORMULAS AND DEMONSTRATION.

Table of Declinations and of Hour Angles.

The declinations are found in column D. The sign of any date is found at the head and foot of the column containing the date, + means north declinations, − means south declinations. H is the hour angle. There are two columns of H, and each of these has two columns of corresponding dates:

	H		D.		H	
−		+		−		+
March 20....	90° 0′	Sept. 23.....	23°27′	March 20...	90° 0′	Sept. 23
March 25....	89 11	Sept. 27.....	23 22	March 15...	90 49	Sept. 18
March 30....	88 21	Oct. 3.......	23 6	March 10...	91 39	Sept. 13
April 4.......	87 35	Oct. 8.......	22 39	March 5...	92 25	Sept. 8
April 9.......	86 53	Oct. 13.......	22 1	March 1...	93 7	Sept. 3
April 14.......	86 17	Oct. 17.......	21 14	Feb. 24......	93 43	Aug. 28
April 19.......	85 46	Oct. 22.......	20 19	Feb. 19......	94 14	Aug. 23
April 24.......	85 24	Oct. 27.......	19 13	Feb. 14......	94 36	Aug. 18
April 29.......	85 10	Nov. 1......	18 0	Feb. 9......	94 50	Aug. 13
May 4.......	85 4	Nov. 6......	16 40	Feb. 4......	94 56	Aug. 8
May 9.......	85 6	Nov. 11......	15 13	Jan. 31.......	94 54	Aug. 3
May 14.......	85 17	Nov. 16......	13 40	Jan. 26.......	94 43	July 29
May 19.......	85 36	Nov. 20......	12 2	Jan. 21.......	94 24	July 24
May 24.......	86 8	Nov. 25......	10 20	Jan. 16	93 52	July 19
May 29.......	86 34	Nov. 30......	8 34	Jan. 12.......	93 26	July 14
June 3........	87 12	Dec. 4.......	6 46	Jan. 7.......	92 48	July 9
June 8........	87 55	Dec. 9..... ..	4 55	Jan. 2.......	92 5	July 4
June 13........	88 42	Dec. 14.......	3 2	Dec. 29.......	91 18	June 29
June 18........	89 30	Dec. 19.......	1 9	Dec. 24.......	90 30	June 24
June 21........	90 00	Dec. 21.......	0 0	Dec. 21.......	90 00	June 21
−		+		−		+

Attention should be called to another feature of the cut, the radius vector and the solar declination arc. If the radius vector be adjusted for declination, and the plane of the arc be adjusted to coincide with the time index, the vector will point to the sun wherever it be in the heavens; that is at any hour of the day or night. Also the plane of

the vector and tangent coincides with the plane of the ecliptic. We have therefore at the same time the relation of our horizon to the ecliptic.

Again we may conceive the radius vector as prolonged to the sun, and then extended still further 92,000,000 miles beyond the sun. This gives us a diameter of the earth's orbit, and the remote extremity is the place of the earth six months ago, or six month hence. Let us now conceive an index attached to that extremity of the diameter, parallel to the tangent index, but reversed, and it is readily seen that it represents the direction in space of the earth's motion in the opposite part of its orbit, and at six months distance in time.

The full comprehension of the facts illustrated by this instrument, will still require thought and study. Illustrative apparatus cannot do away with these; but it may relieve the mental strain, and help it to a successful issue.

THE DISTANCES OF DOUBLE STARS.

BY W. H. S. MONCK, DUBLIN.

For The Messenger.

The difficulty of obtaining accurate measures of the stellar parallax, especially when very small, renders any approximate method of arriving at the same result of considerable interest. In the case of a binary system whose orbit has been computed, I need hardly say that if the mass of the system was known the parallax might be inferred. Doubts no doubt exist at present as to many of these computed orbits; but, unlike the measurements of parallax in which the later are necessarily improvements on the earlier, further observation is certain to remove (in time) all differences as to the orbit. If, under these circumstances we could make any reasonable assumption as to the mass of the system, the parallax and distance could be immediately inferred; and it is to be noted that the mass varies inversely as the cube root of the parallax, so that the latter will only be halved if the former is increased eight-fold. The most natural assumption to start with is that the mass of the system is equal to that of the sun (or rather the solar system). No known system

seems likely to exceed or fall short of this in a degree exceeding eight to one; consequently, if the orbits are correctly computed, the parallaxes arrived at by this method are not likely to be more than double, or less than half, the true parallaxes; and even this degree of approximation is by no means devoid of value. The parallaxes arrived at by this method I venture to designate equivalent parallaxes; and, as the orbits of several binary stars have been differently computed by different astronomers, I give in each case the name of the astronomer whose orbit I have adopted. The following table contains forty-two binaries whose equivalent parallaxes are given. Most of these are small, and I hope to show on a future occasion that the average parallax of other binaries or double stars is still smaller.

	BINARY STAR.	COMPUTER OF ORBIT.	EQUIVALENT PARALLAX.
1.	α Centauri	Doberck	0.928″
2.	Sirius	Colbert	*0.623
3.	η Cassiopeiæ	Grüber	0.257
4.	70 Ophiuchi	Gore	0.228
5.	40 o² Eridani	Gore	†0.223
6.	ξ Boötis	Doberck	0.192
7.	ξ Ursæ Majoris	Duner	0.165
8.	6 Eridani	Downing	0.128
9.	ζ Herculis	Doberck	0.127
10.	γ Virginis	Thiele	0.125
11.	γ Comæ Australis	Gore	0.100
12.	τ Cygni	Gore	0.083
13.	85 Pegasi	Gore	0.080
14.	2173 Σ	Dunér	0.079
15.	η Coronæ Borealis	Doberck	0.076
16.	Castor	Thiele	0.076
17.	ζ Sagitarii	Gore	0.075
18.	42 Comæ Berenices	O. Struve	0.075
19.	44 ι Boötis	Doberck	0.075
20.	σ Coronæ Borealis	Doberck	0.066
21.	3121 Σ	Doberck	0.064
22.	ξ Scorpii	Doberck	0.060
23.	ζ Cancri	Doberck	0.058

* Latest measure, 0.380. † Latest measure, 0.223.

	BINARY STAR.	COMPUTER OF ORBIT.	EQUIVALENT PARALLAX.
24.	3062 Σ	Doberck	0.058
25.	ζ Aquarii	Doberck	0.055
26.	298 ο Σ	Doberck	0.053
27.	β Delphini	Gore	0.052
28.	235 ο Σ	Doberck	0.051
29.	1757 Σ	Gore	0.048
30.	δ Cygni	Behrmann	0.042
31.	ω Leonis	Doberck	0.036
32.	γ Leonis	Doberck	0.036
33.	γ Coronæ Borealis	Doberck	0.034
34.	τ Ophiuchi	Doberck	0.033
35.	λ Ophiuchi	Glasenapp	0.030
36.	36 Andromedæ	Doberck	0.031
37.	1819 Σ	Casey	0.030
38.	4 Aquarii	Doberck	0.028
39.	φ Ursæ Majoris	Casey	0.023
40.	234 ο Σ	Gore	0.020
41.	400 ο Σ	Gore	0.019
42.	14 Orionis	Gore	0.037

The intensity of illumination might, perhaps, enable us to conjecture whether the equivalent parallax was in excess or defect of the true parallax, and this intensity can be easily collected from such works as the *Harvard Photometry*. But there is a preliminary question not so easily disposed of. Supposing the density and illumination for each unit of surface to be constant, great brightness would indicate a smaller mass and larger parallax than that assumed by me; since the smaller the mass the greater will be the proportion which the illuminated surface bears to it. But, on the other hand, there seems reason to think that large stars are at a higher temperature and give more light per unit of surface than smaller ones; and if this is carried far enough to counterbalance the greater (proportional) extent of surface, great brightness must be regarded as a mask of greater mass and smaller parallax than is supposed in the table. The greatest brightness occurs where we should scarcely expect to find it on either hypothesis. Thus γ Leonis gives fully ten times as much light relatively to its equivalent parallax as Sirius, which in its turn is much brighter than α Centauri.

ON TELESCOPES OF SHORT FOCAL LENGTH.

PROFESSOR H. L. SMITH.*

For THE MESSENGER.

I have more than once, in this journal and elsewhere, tried to say a word in favor of a considerable reduction in the focal length of the achromatic telescope. The usual ratio of about 15 to 1 for moderate sized telescopes, and 19 to 1, as in the Lick telescope, necessitates a dome of such size, and also the equatorial stand, that the mere cost of these is quite as much as, or more than, that of the telescope itself; and machinery to enable an observer to reach the eye end of the the telescope at different altitudes is always more or less troublesome. Tolles and Byrne each made for me a telescope 4¼ inches aperture, and about thirty-seven inches solar focus. The performance of these was entirely satisfactory. It is sufficient to repeat what I have before said. They would show all that any telescope of the same aperture would show, and, to say the least, equally well, and were as free from color.

Later Mr. Clacey of Boston made for me a telescope of 42 inches focal length and $4\frac{15}{32}$ inches aperture. This instrument proved to be in every respect the equal of any having the same aperture but usual focal length, and, with the others, was vastly more convenient to handle. With this telescope I made the following measurements of double stars, using a spherical rock crystal micrometer, differing, however, from Dolland's in having the sphere as field instead of eye lens. I need not enter into details of construction, but, as it was a repeating instrument, allowing any number of measurements to be taken, and with great rapidity with only two readings, and requiring no illuminating apparatus, and gave powers of about 175 and 300, with fine definition of the so-called spurious disks, I think the measurements of distance made with it would have probably as much accuracy as could be obtained by the best spider-line micrometer. The value of the scale as used in the Clacey telescope was determined by a great number of measurements of the apparent diameter of Venus in the months

* Hobert College, Geveva, N. Y.

of June and July last. Having determined the maximum value of the angle (when the sphere was rotated 45°), and calling this (r) the value for any other angle (θ) was determined from the formula: $\zeta = r \sin 2\,\theta$.

The stars in the following list which are not binary stars were measured simply as checks, and, as it is my first essay in this kind of work, I cannot claim any especial accuracy.

The position angles are really much more difficult to be observed correctly than might at first appear. The components must not only be in the exact center of field, or very near it, but should bear the test of rapid change from side to side repeatedly without being thrown out of straight line. Such as they are I give them below, and they will at least show the optical capacity of the telescope. The measurements were all made in the months of June and July, 1887:

	APPROX. A. R. h m	DEC. ° ′	POS. °	DIST. ″
γ Virginis	12 36	− 0 50	338.96	6.12
Σ 1835, XIV. 69	14 18	+ 8 59	189.00	6.79
π Boötis	14 35	16 58	105.03	6.53
ε Boötis	14 40	27 32	327.79	2.47
ξ Boötis	14 46	19 33	259.60	3.02
λ Ophiuchi	16 25	2 14	41.05	1.38
ζ Herculis	16 37	31 48	87.50	1.44
α Herculis	17 09	14 31	116.47	4.99
ρ Herculis	17 20	37 15	311.66	3.73
95 Herculis	17 56	21 36	263.00	6.05
τ Ophiuchi	17 57	− 8 11	256.00	1.67
70 Ophiuchi	18 00	+ 2 32	5.77	1.95
ε^1 Lyræ	18 41	39 33	16.92	3.42
ε^2 Lyræ	18 41	39 29	133.36	2.52
β Cygni	19 41	44 52	318.80	1.60
π Aquliæ	19 43	11 31	121.86	2.13
γ Delphini	20 42	15 44	272.51	11.00
ε Equlei, A. B.	20 53	3 54	284.40	1.20
Equlei, A. C.	20 53	3 54	77.01	10.77
61 Cygni	21 01	38 12	116.80	22.15
μ Cygni	21 39	28 15	119.50	3.79
ζ Acquarii	22 23	− 0 35	329.88	3.03

NOTE.—The Clacey objective with which the preceding observations were made having recently passed into the posses-

sion of Messrs. Warner & Swasey, I have been able to test still further the capabilities of short-focus glasses by the aid of Mr. Herbert A. Spencer, already so widely known for his unrivalled microscopical objectives, which are unsurpassed even by the exquisite combinations produced by Zeiss and Abbe at Jena. Understanding thoroughly the necessity of perfect figuring and centering, and having the necessary skill to do this, he was ready to undertake the construction of an objective of considerably shorter focal length than I was willing to risk; and a compromise was effected on a ratio of 7 to 1, and accordingly I am now in possession of an object glass almost 5 inches clear aperture ($4\frac{7}{8}$), and 35 inches solar focus; and the remarkable thing about it is, and illustrating the extreme care bestowed in the figuring and perfect centering of the lenses that the lenses have *never been touched since first taken from the polisher*, and since their centering (which was done optically, and with greatest care). No refiguring or retouching of any kind was required. The color correction is as perfect as with any telescope made with the same materials (Chance's glass) of the usual focal length. This little (so far as length is concerned) telescope bears a power of 400 on Saturn with great distinctness, and the views it gives of Jupiter and Mars are fully equal to any I have ever had with a telescope of five inches aperture. So far as double stars are concerned, the closest I have yet seen with is μ^2 Boötis. Such stars as λ Ophiuchi are widely separated with a power of about 200, and readily seen with 150. ζ Herculis, which is always troublesome with a refractor of less than six or seven inches (as the small companion falls on the first diffraction ring), I have seen quite widely separated, and with scarcely a trace of rings with a power of about 400; the discs neat and round. This magnification was produced using really a compound microscope, which Mr. Spencer prepared, having a single system specially corrected for the objective and an ordinary Huggenian for the ocular; with this arrangement and which appears to answer even better than the "Barlow lens," very high powers can be had withuot having recourse to minute lenses; I have however had almost if not quite as good results in this star with a Barlow lens made by Spencer, and giving nearly the same amplification using the ordinary negative eyepiece, which alone would

still show the dusky companion with a power of about 225. Whatever may be the theoretical objections, or the difficulties for ordinary opticians, there seems to be no real necessity for such long tubes as are now usually supplied.

The little observatory which, with the dome and all complete, cost only some $40 (independent of the pier), and which is only 6½ feet internal diameter, is quite large enough to carry a 7-inch glass under it with ease, and I hope ere long to give some account of what such a glass will do. For photographic work one need hardly remark upon the immense advantage of reduction of focal length. Dr. Gill has spoken very favorably of a telescope of 3 inches aperture and only 18 inches focal length made for him by Schroeder. This was a triple object glass, and he seemed to think that this form would be necessary in order to effect the reduction in length. Mr. Spencer has demonstrated practically that this is not necessary, and, indeed, with the telescope made for me, there is less of outstanding (secondary) color about Jupiter (none at all with Saturn) than is usually seen in telescopes.

I had been thinking of mounting one of these short telescopes as a comet seeker, bending the tube in the middle at right angles, placing at the angle one of Brashear's flats of about half the diameter of the objective, and rotating, for altitude, about the eye tube somewhat as described by Mr. Hill for a reflector in the June number of this journal, and which is an ingenious modification of Miss Caroline Herschel's, as figured in Smyth's "Celestial Cycle," Vol. II.

THE GREAT LICK TELESCOPE.*

PROFESSOR E. S. HOLDEN.

The Lick Observatory is beginning to present a very different appearance, both by night and by day, from the one it lately had during its period of construction. At night the windows which have been so long dark, show the lamps of the astronomers gleaming through them. The shutters of the observing slits are open, and the various instruments

* Extracts from a private letter to a friend, published in the San Francisco *Times*, July 11, 1888.

are pointed through them at the sky. The actual work of observing has begun, and the purpose for which the Observatory was founded—to be "useful in promoting science" —is in the way of being acomplished. Professor Schaeberle, late of Ann Arbor, has commenced the long task which has been assigned to him, namely to fix with the very highest degree of precision possible to modern science, the position of the "fundamental stars" with the Repsold Meridian Circle. The time-service for railway use is now conducted by Mr. Hill (late assistant to Professor Davidson), which leaves Mr. Keeler free to make the necessary studies of the great star spectroscope, which is one of the most important accessories of the 36-inch equatorial. Mr. Barnard is assiduously observing comets and nebulæ with the fine 12-inch Equatorial, and getting the photographic appliances in readiness to be used with the great telescope. He has already discovered twenty new nebulæ, found in the course of his sweeps for new comets. To show you some of the advantages of our situation here, I may tell you that Professor Swift of Rochester has a fine 16-inch Equatorial by Alvan Clark, and has discovered many faint nebulæ by its use. Two nights ago Mr. Barnard was examining some of these excessively faint objects by means of the 12-inch telescope (which gives only a little more than half the light of Professor Swift's), and in the field of view where Professor Swift had mapped only one nebulæ Mr. Barnard found three, two being, of course, new. This is due, not only to the observer's skill and keenness of eye, but in great measure to the purity and transparency of our atmosphere here.

The Eastern astronomers have given up the observation of Olber's comet, which is now only about $\frac{7}{100}$ as bright as last year, but Mr. Barnard has succeeded in following it up to last night, when it finally became too faint to be seen even here. These observations, which are several weeks later than those of other observatories, are of real value, as they determine a larger arc of the comet's orbit and enable its motion to be fixed with a much higher degree of accuracy. Mr. Keeler is just reducing his observations of the faint satellites of Mars, made with the large telescope during the past months. You can gain some sort of an idea of the immense advantage of the great telescope in such obser-

vations, when I tell you, that the brightness of the satellites as observed by him was only about one-sixth of their brightness at the time of their discovery. We can then make satisfactory observations of objects which are *six times fainter* than those very minute satellites of Mars were when Professor Hall discovered them in 1877 with the great telescope at Washington. I am becoming familiar with the performance of the large telescope and learning how to get the very best work from it. It needs peculiar conditions; but when all the conditions are favorable its performance is superb. I am, as you know, familiar with the action of large telescopes, having observed for many years with the great refractor at Washington, but I confess I was not prepared for the truly magnificent action of this, the greatest of all telescopes, under the best conditions. I have had such views of the bright planets (Mars and Jupiter) of nebulæ, the Milky Way and some of the stars, as no other astronomer ever before had. Jupiter, especially, is wonderfully full of details that I had not begun to see before. The discs of his moons can be readily noted in smaller telescopes; but here they are full and round, like those of planets. I am almost of the opinion that the curve of Jupiter's shadow might be seen on the surfaces, under favorable circumstances, when the satellites suffer eclipse.

There is reason to believe that the satellites of Jupiter, like our own moon, present always the same face to their planet. This can be studied here to great advantage if the discs present any of the markings which are reported by other observers. The Milky Way is a wonderful sight, and I have been much interested to see that there is, even with our superlative power, no final resolution of its finer parts into stars. There is always the background of unresolved nebulosity on which hundreds and thousands of stars are studded—each a bright, sharp, separate point. The famous cluster in Hercules (where Messier declared he saw "no star" is one mass of separate individual points. The central glow of nebulosity is thoroughly separated into points. I have been specially interested in looking at objects which are familiar to me in other telescopes, and in comparing our views with the drawings made by Lord Rosse with his giant six-foot reflector. Theoretically his telescope should

show more than ours, for his collected the most light. But the *definition* (sharpness) of his is far behind our own, as we constantly see. For example, the ring nebula in Lyra is drawn by Lord Rosse with no central star. At Washington one small star can be seen in the midst of the central vacuity, but here we are sure of seeing three such at least. These are interesting on account of their critical situation in the nebula, not simply as stars.

The great Trifid and Omega nebulæ are wonderful objects here. Not only is a vast amount of detail seen here which can not be seen elsewhere, but the whole aspect of them is changed. Many points that are doubtful with other telescopes are perfectly simple and clear here. I have always considered that one of the great practical triumphs of this telescope would be to settle, once for all, the doubts that have arisen and that will arise elsewhere. Now I am sure that we shall be able to do this, and in a way to end controversy.

Of course you understand that the period of construction here is not yet quite over, though, I am thankful to say it is nearly ended. We have been making our observations so far under great disadvantages, and now that we see the way out of most of them, and look forward to work uninterrupted by machinists and constructors we begin to realize the opportunity. It really takes time to understand how to utilize it in the very best way. A great telescope is not like an opera glass, which can be taken out of one's pocket, and which is at once ready for use. It is a delicate and complicated machine which demands a whole set of favorable conditions for its successful use. Every one of these conditions has to be studied and understood, so that it can be commanded and maintained. We have been busy night and day in this work and in completing the thousand arrangements and contrivances which are essential in order to turn this vast establishment from a museum of idle instruments into a busy laboratory where the inner secrets of the sky are to be studied. We feel sure now that in a comparatively short period we shall be in full activity. In the mean time every one of us is doing his best under the conditions.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be in conjunction with the moon August 5, and, on the same day a few minutes later, the planet passes into its ascending node. August 10 it is in perihelion of its orbit; the 13th, in conjunction with Saturn; 23d, in conjunction with the sun; Sept. 6, in conjunction with the moon again, the planet being 3° 46′ south; Sept. 18, in conjunction wi h Venus, Mercury being 1° 39′ south. About August 5 Mercury ought to be seen by naked eye observation, as it rises so much in advance of the sun.

Young observers who have not seen Mercury with the telescope nor by the unaided eye will be richly repaid for all trouble to get such observations. In the small telescope, under favorable times for observation, the phase of the planet is readily seen. If, however, the atmosphere is unsteady the teminator will not show the clean, definite outline that experienced observers now anxiously look for in order to gain more definite knowledge of its surface markings. When the air is clear and steady some phases of Mercury are hard to observe well because of the irradiation, for the terminator of phase will apparently extend beyond its actual outline. The reason for this is plain to students of elementary physics and does not need to be stated here. The young observer's note book may profitably contain the following points for Mercury.

1. "Mercury twinkles like a star," is the statement of some text-books on astronomy. Good observers do not believe this. Study the appearance of a bright fixed star and the atmospheric conditions under which Mercury is seen.

2. The terminator is uneven. Why? Is it uneven surface, or the effect of irradiation?

3. Small telescopes increase irradiation proportionately more than large ones.

4. The spots on the surface of Mercury do not seem to be permanent.

5. The half-moon phase is not, generally speaking, at greatest elongation, as the text-books often say.

Venus is too near the sun to be an object of interest during the months of August or September. The planet is moving southward in declination during both months and hence reaches a comparatively low altitude at meridian passage.

Mars is an evening star in the constellation of Libra, and will be in conjunction with the moon August 13, and also Sept. 10. On the last named day Mars will be in conjunction with Jupiter, the latter being 2° 12′ north. In his illustrated notes on the planets, June issue of the *Journal of the Liverpool Astronomical Society*, Mr. W. F. Denning particularly describes the surface of Mars, which has attracted unusual attention of late. He says that the canal-shaped markings of Chiaparelli were seen, but that their structure and aspect seemed to him very different from the appearance of those figured on Chiaparelli's charts. They are not so definite and hard in outline in Mr. Denning's 10-inch reflector, nor does he get the net-work of bold, straight lines seen by Chiaparelli with an 8-inch refractor at the Observatory of Milan. On the contrary Mr. Denning does see a great variety of markings which he finds it difficult to reproduce in drawing on account of the many delicate gradations of light and shade. He also noticed the bright regions near the seas lately as very conspicuous. The "Fontana Land," so-called in Green's charts, showed excessive whiteness in great contrast with the surrounding regions. It produced an effect like that of the brilliant ice cap. This raises the question whether the equatorial regions of Mars have great snow fields or not; or is it possible that astronomers have wrongly interpreted the cause of the polar spots? These markings have been seen with very small instruments, under favorable conditions, by experienced observers. The northern polar cap is more difficult to observe than the southern. April last Denning saw it in full moonlight, and noticed its projection beyond the limb of the planet. Webb attributes the cause of this to irradiation. The especially favorable opposition of 1892 is waited for with deep interest, because then the planet will be nearer than since 1877. The two minute satellites of Mars have been followed and systematically observed by the aid of the great Lick telescope during this late opposition.

Jupiter is now a noble object in the telescope. It will be

in quadrature with the sun Aug. 19; in conjunction with β^1 Scorpii, Sept. 22, the planet being 28′ south of the star. That which attracted most attention at Carleton College Observatory during the last month was the appearance of the great southern belt. There was no especially marked change observed, but the depth of its color, the distinctness and unusual regularity of its outlines were noticeable features. The markings of Jupiter's surface can be seen by the aid of small telescopes having good defining powers, though the great red spot, which is now rather faint, requires a telescope of greater aperture for satisfactory observation. A point of some interest that should not be forgotten is the occultation of a 7.7 magnitude star by the planet Jupiter, August 7, at 9*h* 22*m* P. M., central time. The maximum duration is 358 minutes. This is the only predicted occultation of a star by a planet that we know of for the rest of the year 1888.

Saturn is not in position for observation for the months of August and September.

Uranus, August 5, will be about 1° east of a third magnitude star, known as δ in the constellation of Virgo. August 11 the planet is in conjunction with the moon, the latter being 4° 44′ north. Sept. 19 it is in conjunction with Mercury, and the same day, three hours later, Mercury is in conjunction with Venus, the three planets forming nearly a straight line north and south, little more than 1½° long.

Neptune is in Taurus, half way between the Pleiades and the bright red star, Aldebaran. It can be seen only by the aid of the telescope.

MERCURY.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Aug. 6	7 59.9	+20°40′	3 26 A. M.	10 57.1 A. M.	6 28 P. M.
16	9 18.1	+17 21	4 21 "	11 36.0 "	6 51 "
26	10 35.6	+10 40	5 28 "	12 14.0 P. M.	7 00 "
Sept. 5	11 42.2	+ 2 55	6 26 "	12 41.0 "	6 56 "
15	12 40.1	− 4 36	7 14 "	12 59.5 "	6 45 "
25	13 32.3	−11 18	7 54 "	1 12.1 "	6 30 "

VENUS.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Aug. 5	9 33.7	+15 56	5 26 A. M.	12 35.0 P. M.	7 44 P. M.
15	10 21.8	+11 46	5 53 "	12 43.3 "	7 34 "
25	11 08.1	+ 7 05	6 20 "	12 51.0 "	7 22 "
Sept. 5	11 58.0	+ 1 33	6 47 "	12 56.7 "	7 06 "
15	12 43.0	− 3 35	7 13 "	1 02.3 "	6 52 "
25	13 28.5	− 8 37	7 39 "	1 08.3 "	6 37 "

MARS.

	R. A. h m	Decl.	Rises. h m	Transits. h m	Sets. h m
Aug. 5	14 19.9	−15°17′	0 20 P. M.	5 20.7 P. M.	10 22 P. M.
15	14 42.7	−17 12	0 11 "	5 04.1 "	9 57 "
25	15 07.1	−19 02	0 04 "	4 49.2 "	9 34 "
Sept. 5	15 35.5	−20 53	11 59 A. M.	4 34.6 "	9 10 "
15	16 03.7	−22 21	11 54 "	4 23.1 "	8 52 "
25	16 32.8	−23 33	11 50 "	4 12.9 "	8 36 "

JUPITER.

Aug. 5	15 38.6	−18 44	1 52 P. M.	6 38.7 P. M.	11 25 P. M.
15	15 40.8	−18 54	1 16 "	6 01.6 "	10 47 "
25	15 44.1	−19 07	0 41 "	5 25.6 "	10 10 "
Sept. 5	15 48.8	−19 24	0 05 "	4 47.9 "	9 30 "
15	15 54.3	−19 42	11 32 A. M.	4 14.0 "	8 56 "
25	16 00.6	−20 03	11 01 "	3 40.9 "	8 21 "

SATURN.

Aug. 5	8 52.7	+18 15	4 35 P. M.	11 54.0 A. M.	7 13 P. M.
15	8 58.0	+17 55	4 02 A. M.	11 20.0 "	6 38 "
25	9 03.0	+17 35	3 30 "	10 45.7 "	6 02 "
Sept. 5	9 08.4	+17 13	2 53 "	10 77.8 "	5 22 "
15	9 13.0	+16 54	2 16 "	9 29.6 "	4 43 "
25	9 17.3	+16 36	1 43 "	8 54.5 "	4 06 "

URANUS.

Aug. 5	12 52.8	+ 4 57	9 30 A. M.	3 53.2 P. M.	10 16 P. M.
25	12 56.0	+ 5 19	8 13 "	2 37.8 "	9 02 "
Sept. 15	13 00.3	+ 5 46	6 52 "	1 17.7 "	7 44 "

NEPTUNE.

Aug. 5	4 01.3	+18 58	11 42 P. M.	7 04.1 A. M.	2 27 P. M.
25	4 02.3	+18 59	10 24 "	5 46.4 "	1 09 "
Sept. 15	4 02.3	+18 58	8 57 "	4 19.8 "	11 42 A. M.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. Point. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
Aug. 13	ξ^1 Libræ	6	8 52	19	Star 1.8′ N. of moon's limb.		
17	30 Sagittarii	6½	8 58	131	10 00	228	1 02
17	31 Sagittarii	6½	9 36	76	10 56	277	1 20
20	γ Capricorni	3½	6 02	77	7 05	265	1 04
20	δ Capricorni	2½	10 08	37	11 18	285	1 11
26	μ Ceti	4½	15 47	76	17 15	225	1 28
29	*m* Tauri	5½	14 20	107	15 21	216	1 01
30	χ^1 Orionis	4½	12 58	347	Star 0.4′ N. of moon's limb.		
30	χ^2 Orionis	6	13 00	167	Star 2.0′ S. of moon's limb.		
Sept. 1	79 Geminorum	6½	14 37	39	15 17	315	0 40
17	50 Aquarii	6	11 11	56	12 31	250	1 20
17	B. A. C. 7835	6½	14 46	70	15 48	243	1 01
18	ψ^1 Aquarii	4	12 29	9	13 19	291	0 51
18	ψ^2 Aquarii	4	13 22	93	14 25	208	1 03
27	15 Geminorum	6½	12 02	80	13 06	259	1 04
27	16 Geminorum	6½	12 32	169	Star 3.0′ S. of moon's limb.		
28	56 Geminorum	5½	13 19	165	Star 1.8′ S. of moon's limb.		

Phenomena of Jupiter's Satellites.

Central Time. d	h m			Central Time. d	h m		
Aug. 7,	7 41	P. M.	II Tr. In.	Aug. 25,	6 49	P. M.	III Sh. In.
7,	9 07	"	III Ec. Dis.	25,	7 16	"	II Sh. Eg.
8,	7 02	"	I Tr. In.	31,	7 28	"	I Tr. In.
8,	8 28	"	I Sh. In.	Sept. 1,	7 17	"	II Tr. Eg.
8,	9 26	"	I Tr. Eg.	1,	7 19	"	II Sh. In.
8,	10 42	"	I Sh. Eg.	1,	7 52	"	III Tr. Eg.
9,	7 23	"	II Ec. Re.	1,	8 08	"	I Ec. Re.
9,	7 55	"	I Ec. Re.	8,	6 38	"	I Oc. Dis.
14,	7 45	"	III Oc. Dis.	8,	7 22	"	II Tr. In.
14,	9 52	"	III Oc. Re.	9,	7 21	"	I Sh. Eg.
15,	9 06	"	I Tr. In.	10,	7 14	"	II Ec. Re.
17,	7 06	"	I Sh. Eg.	12,	6 58	"	III Ec. Re.
23,	7 31	"	II Oc. Dis.	16,	7 03	"	I Sh. In.
23,	8 16	"	I Oc. Dis.	17,	6 26	"	I Ec. Re.
24,	6 48	"	I Sh. In.	19,	6 27	"	III Oc. Re.
24,	7 45	"	I Tr. Eg.	26,	6 53	"	II Sh. Eg.

Great Red Spot on Jupiter—Times when its Zero Meridian passes the Centre of Jupiter's Disc.

Central Time. d	h m		Central Time. d	h m		Central Time. d	h m	
Aug. 1,	8 53.3	P. M.	Aug. 18,	7 58.8	P. M.	Sept. 4,	7 06.4	P. M.
3,	2 40.5	A. M.	20,	1 47.0	A. M.	6,	12 54.7	A. M.
3,	10 32.0	P. M.	20,	9 38.6	P. M.	6,	8 46.3	P. M.
4,	6 22.6	"	21,	5 29.3	"	8,	2 33.8	A. M.
6,	12 10.8	A. M.	22,	11 17.5	"	8,	10 25.4	P. M,
6,	8 01.4	P. M.	23,	7 08.2	"	9,	6 16.1	"
8,	1 49.6	A. M.	25,	12 56.5	A. M.	11,	12 04.4	A. M.
8,	9 41.1	P. M.	25,	8 48.1	P. M.	11,	7 56.1	P. M.
9,	5 31.7	"	26,	4 38.8	"	12,	3 46.8	"
10,	11 19.9	"	27,	10 27.1	"	13,	9 35.2	"
11,	7 10.6	"	28,	6 17.7	"	14,	5 25.9	"
13,	12 58.8	A. M.	30,	12 06.0	A. M.	15,	11 14.3	"
13,	8 50.3	P. M.	30,	7 56.7	P. M.	16,	7 05.0	"
15,	2 37.7	A. M.	Sept. 1,	1 45.0	A. M.	18,	8 45.0	"
15,	10 29.2	P. M.	1,	9 36.6	P. M.	19,	4 35.8	"
16,	6 19.9	"	2,	5 27.4	"	20,	10 24.1	"
18,	12 08.1	A. M.	3,	11 15.7	"	21,	6 14.9	"

Phases of the Moon.

	Central Time. d	h m	
New Moon	Aug. 7,	12 20.9	P. M.
First Quarter	14,	10 44.0	A. M.
Full Moon	21,	10 20.3	"
Last Quarter	29,	8 17.9	"
New Moon	Sept. 5,	10 56.1	P. M.
First Quarter	12,	3 59.9	"
Full Moon	19,	11 24.3	"
Last Quarter	28,	2 30.2	A. M.

Solar Prominences. The new Fauth & Co. spectroscope belonging to Carleton College Observatory is being employed in connection with the 8¼-inch equatorial in the study of the solar chromosphere and prominences. The spectroscope is

provided with a fine prism and a diffraction grating of speculum metal ruled by Brashear with Professor Rowland's ruling engine, 14,400 lines to the inch. There are 27,700 lines upon the grating, each about an inch and three-eighths in length, giving a ruled area about 2 by 1⅜ inches. Thus far the grating only has been used, and has given great satisfaction. The lines of the principal spectrum are very distinct and widely separated. Some very satisfactory and exceedingly interesting views of the chromosphere and prominences have been obtained in the great *C* line in the red, with the slit opened from a half to one and a half millimeters. A millimeter at the focus of the 8¼-inch equatorial corresponds to about 67″ of arc. None of the prominences observed so far have had a height greater than 80″, but some have shown much more of detail in this structure than is ordinarily shown in drawings of these phenomena. One, especially, was observed June 25, at 3:45 P. M., which was full of minute detail, which at 5 P. M. had completely changed. On June 28 a very rapidly changing eruptive prominence was observed on the N. E. limb of the sun, at about 50°. From 3:50 to 4:15 P. M. five sketches were made, each showing marked difference in detail. July 18, at 11 A. M., a very low prominence was observed on the west limb, lying very near, if not exactly over, a large spot which had been seen near the edge of the disc on the preceding day and was surrounded by brilliant faculæ. The peculiarities of this prominence were its extraordinary brightness, exceeding that of the chromosphere itself, and a long extension down through the chromosphere into the black line of the photosphere. H. C. W.

The total eclipse of the moon, July 22, was a beautiful sight. The atmosphere was very clear and the copper color of the moon in its total phase was certainly stronger than ever before seen by us. The predicted time for all phases observed was very closely verified.

Professor W. A. Crusenberry, Garfield University, Wichita, Kansas, observed the eclipse with a 6½-inch reflector. He reports that from 10:58 P. M. until the moon left the shadow, the telescope was quite constantly used. The air was clear but unsteady. "The copper hue of the moon's disc,

contrary to commonly published statements, was plainly visible on the dark side fifteen minutes after the moon entered the shadow, and to within fifteen minutes of its leaving the shadow. While the moon's disc was half covered, and during totality, the well known craters and other markings could be distinctly seen on the shaded part."

Professor Comstock, Director of the Washburn Observatory, Madison, Wisconsin, observed twenty-two occultations of stars, 9 to 10.5 magnitude, during the eclipse.

Eclipse of the Sun. The fifth and last eclipse for the year 1888 will occur August 7. It will be a partial eclipse of the sun visible only in the Arctic ocean, Norway and Sweden, portions of Denmark and Greenland and the extreme northern parts of North America and Asia. Less than two-tenths of the diameter of the sun will be covered.

Minor Planets. Mr. Borrelly's supposed discovery of a new minor planet on May 12, turns out to be (116) *Sinora.* So Palisa's discovery of May 16 is number (278), and has been named *Paulina.*

EDITORIAL NOTES.

The next issue of this journal will be for the month of October. The full description, with illustration, of the new Observatory of Carleton College, which was promised for this month, must be deferred until next time, as the cuts are not ready.

Professor H. A. Howe, department of Mathematics and Astronomy in Denver University, Colorado, has visited nearly all the prominent observatories in the United States recently. His tour has been one of inspection and counsel with astronomers to aid him in constructing his own new observatory which is to go forward as rapidly as possible. His visit at Carleton Observatory on July 18, for a single day, was a genuine delight to us, socially, mathematically, astronomically and every other way, for it brought back to us vividly the times of 1876 when we worked together, as students, in the Cincinnati Observatory, under that most

genial and helpful instructor, Professor Ormond Stone, now Director of the Leander McCormick Observatory, University of Virginia.

At the last meeting of the Board of Trustees of Carleton College, Dr. H. C. Wilson was elected Assistant Professor of Astronomy. This is the first permanent position, for an assistant professor that the college has established in any of its departments. This institution is only twenty years old, and yet its official management has been able to honor thus one of its most worthy graduates, a member of the class of 1880.

Fifty Years of American Astronomy was the title of an address delivered June 25, by Professor T. H. Safford, Director of the Field Memorial Observatory of Williams College, at Williamstown, Mass. This semi-centennial occasion was one to commemorate the erection in 1838 of the first college observatory in the United States. Mr. David Dudley Field, of New York, was fittingly chosen to preside, as he was the founder, in 1869, of the Field Memorial Professorship of Astronomy in Williams college, and five years later, the generous donor of the Field Memorial Observatory for the same institution.

The MESSENGER hopes later to publish the address of Professor Safford, which is said to be a most important piece of historical research, and therefore richly deserving a permanent place in the general and popular records of our science.

The Study of Meteorites. Last month we published two of the three main propositions which Professor Newton made the basis of a paper "Upon the relation which the former orbits of those meteorites that are in our collections, and that were seen to fall, had to the earth's orbit." The third proposition, not then known, was: "The perihelion distances of nearly all the orbits in which these stones moved were not less than 0.5 nor more than 1.0, the earth's radius vector being unity."

We were sorry that we were not able to get the whole paper for our June issue. It was published entire in the July number of the *American Journal of Science*.

Comet a 1888 (*Sawerthal*). March 30. Tail very bright along the central axis, much fainter on either side and again brighter along the edges. Probably three tails. Nucleus elongated in direction of axis, or double.

June 1. There are three tails—the central one bright, the

MARCH 30.

JUNE 1.

others very faint. The tail to the right is slightly shorter and fainter than the one to the left. Nucleus round.

Evidently the change in the appearance of the tail can be accounted for by increase of distance for March 30, until the fainter parts disappeared. F. P. LEAVENWORTH.

Haverford College Observatory.

Observation of Comet 1888 a (Sawerthal.)

1888, Haverford Mean Time.	*	No. of Comp.	Comet — Star.		α	δ	log p Δ for α	log p Δ for δ
h m s			m s	′ ″	h m s	° ′ ″		
May 2, 15 41 12	1	23 5	+ 2 36.72	+ 5 15.2	23 28 46.22	+ 27 52 14.3	n 9.694	0.623
6, 15 20 32	2	24 7	— 2 17.24	— 7 3.8	23 37 56.92	+ 29 54 19.8	n 9.709	0.628
20, 15 36 8	3	30 5	— 0 37.23	— 2 .91	0 7 1.47	+ 35 57 37.5	n 9.716	0.492

Mean Places for 1888.0 of Comparison Stars.

*	α	Red to App.	δ	Red to App.	Authority.
	h m s	s	° ′ ″	″	
1	23 26 10.08	— 0.58	+ 27 47 10.3	— 11.2	Weisse's Bessel 524
2	23 40 14.72	— 0.56	+ 30 1 35.2	— 11.6	Weisse's Bessel 832
3	6 7 39.01	— 0.31	+ 35 59 58.7	— 12.1	Weisse's Bessel 158

May 6, Nuclues faint and ill-defined, perhaps on account of clouds.

May 20, Nucleus round and well defined surrounded by an envelope much elongated in a direction at right angles to the axis of the tail. Tail much fainter than the envelope. Nucleus estimated of the 8 magnitude as compared with the 9th magnitude comparson star. On March 30, the nucleus was observed to be decidedly enlongated in the direction of the axis of the tail.

A comparison of the observation of May 20, with the ephemeris computed by Professor Boss, *Astronomical Journal*, No. 171, page 22, gives O − C; $\Delta\alpha = -2.5s$, $\Delta\delta = -25''$.

F. P. LEAVENWORTH,

Haverford College Observatory, May 26, 1888.

Salaries at Lick Observatory. The Mining and Scientific Press, (San Francisco, June 23)issued a special edition of 32 pages, called the Lick Observatory edition. In that paper will be found the most complete account of this great Observatory that has yet appeared in print. Accompanying the descriptive reading matter, which fills thirteen pages, is found over thirty cuts, large and small, giving views of the buildings, grounds and instruments. The pictures of Mr. Lick, the founder, and Professor Holden, the Director, are also given.

The salaries of the observing corps are as follows:

Professor Holden, as Director and Astronomer $5,000; S. W. Burnham, astronomer, $3,000; J. M. Schaeberle, astronomer $2,000; J. E. Keeler, astronomer, $1,400; E. E. Barnard, astronomer, $1,200; C. B. Hill, assistant astronomer, secretary and librarian, $1,000. This number of the *Press* is an excellent one to file for reference.

Elements of the Great Comet of 1882 (*Comet II., 1882*). In the year 1884 Mr. Winlock, of the United States Naval observatory, drew my attention to the orbit of Comet II., 1882, recommending that a determination of the elements be made from observations of the United States Naval Observatory.

Although the determination of the elements was completed in 1884, other work and subsequent travels in Eu-

rope prevented the further prosecution and publication of the work.

As the elements computed by me are, as far as I am aware, the only elements of the Comet II. 1882 determined exclusively from meridian observations of the United States Naval Observatory, and as the orbit presents many interesting features I here give the elements of this comet determined by me:

ELEMENTS OF COMET II. 1882.

$$T = (1882)\ \text{Sept. } 17.0076723\ \text{Wash. M. T.}$$

$$\left.\begin{aligned} \pi - \Omega &= 69^\circ\ 36'\ 9''.01 \\ \omega &= 346\ \ 1\ \ 6.93 \\ i &= 141\ 59\ 54.00 \end{aligned}\right\}\text{Mean Equinox.}$$

$$\begin{aligned} \log a &= 1.9066282 \\ P &= 718.862\ \text{years.} \\ \varphi &= 89^\circ\ 12'\ 31''.61 \\ \log q &= 7.8859571-10 \end{aligned}$$

COMP. OBS.

	$\cos\beta\, d\lambda$	$d\beta$
Sept. 19.	0″.00	0″.00
Nov. 15.	00 .11	00 .42
Dec. 4.	0 .00	0 .00

From other Washington observations and repeated calculations the values of 704 years, 712 years, and 716 years for the period of this comet, were obtained.

The period of 718.862 years obtained from the meridian observations seems, therefore, to be very near the truth.

Baltimore County, M. D. GUSTAVE L. RAVENE.

The Markings of Jupiter. Some observers are calling attention to the color of the prominent belts on the planet Jupiter, claiming that a reddish tinge is more noticable of late than usual, and suggesting that the color here shown so much resembles that of the great red spot that possibly the same causes are directly or remotely concerned in producing both phenomena.

J. A. Brashear, of Allegheny City, is now in Europe on a vacation trip. In June he was in London, Paris and Munich. In August in Berlin and Glasgow. He expects to attend the meeting of the British Association Sept. 5. He will visit the principal observatories of Europe and distinguished makers of astronomical instruments.

Value of Filar Micrometer. One of the methods given by *Chauvenet* for determining the value of one turn of the filar micrometer is to measure the angular space, between two stars (for example), and divide the known angle by the divisions of the micrometer subtended thereby, etc. Of course the most easily practicable method with an equatorial is to measure the $\Delta\delta$ directly, and then divide the known $\Delta\delta$ in seconds of arc (corrected for refraction), by the observed turns of the micrometer. *Chauvenet* suggest certain pairs of stars in the "Pleiades."

I have found the stars 12 and 13 Comæ an excellent pair for applying this method. The declinations, and proper motions have been well determined, and are found in various catalogues. Doubtless better values may easily be found for those I have used, which are as follows:

δ, 1888.0

Authority.	Wt.	12 Comæ.	13 Comæ.
Yarnall	1	+26°28′05.9″	+26°43′——
Safford	2	04.6	10.9″
Harvard ('72.)	2	03.8	10.8
Harvard ('75.)	2	03.5	11.1
Adopted δ	=	+26°28′04.24″	+26°43′10.93″
Precession	=	−19.997″	−19.984″
Proper motion	=	+ 0.0035″	− 0.0197″
R. A. 1888	=	12*h* 16*m* 52.5*s*	12*h* 18*m* 41.4*s*

In this pair we have a difference of about 906″, about the largest practicable with the usual micrometer eyepiece and with the stars only two minutes of arc apart, and of the same magnitude.

The value of one turn of the micrometer belonging to the equatorial of this observatory, I have determined from transits of stars of various declinations, etc., = 23″.087. A set of eight determinations by above pair, taken last night gave $\Delta\delta = 39t.211$: the distance, corrected for refraction, being 906″.2, we have the value of one turn = 23″.111; a set of transits of θ Boötis immediately afterwards gave one turn = 23″.104. CHAS. B. HILL.

Chabot Observatory, Oakland, Cal.,
May 23, 1888.

Professor Newton's article on the orbits of aerolites is reprinted in Nature, July 12.

Old and New Astronomy. Parts II. and III. of this new work by Mr. Proctor have been received. Part II. concludes the second chapter, which has for its theme "Ancient and Modern Studies of the Earth's Shape," and begins chapter number three. Two full-page stereographic charts in colors, representing the northern and southern hemispheres of the earth, appear early in the second chapter. Following these are cuts illustrating the effects of the earth's curvature on bodies at a distance on its surface; the effect of refraction in diminishing the apparent curvature; illusions affecting the earth's appearance as seen from a balloon; how to measure the curvature; the earth's true figure, showing the comparative height of the atmosphere, and, finally the various modes of mapping its surface. These illustrations pertaining to the study of the earth's shape are good, but we wonder at the use of filling fifty-one pages on this theme with so much of detail. Chapter III. discusses the apparent motions of the sun, moon and planets, referring first to the notions of the ancients and their modes of study, and the values of the obliquity of the ecliptic obtained by them. Then the reader is asked to follow the sun's progress through the twelve signs of the Zodiac, which path is illustrated by twelve full-page maps, each showing the relation of a particular sign to the constellation of the Zodiac, by the same name, and others contiguous to it. Next is given the way in which Hipparchus determined the position of the sun's perigee and apogee, and the ground of his error relating to the eccentricity of the sun's apparent orbit. This is a piece of interesting history and valuable in detail. The supposition setting forth how the ancients *may* have begun the study of the moon and pursued it, is a good piece of imagination and quite like that which often occurs in this new work at the beginning of new subjects. Nothing need be said against it, if the reader is aware that such easy and convenient introductions are no part of the known facts, or that they necessarily at all belong to the history of these noble themes. The emphasis should be placed on "probably," "doubtless," "perhaps," and such key words in these lengthy passages. That the author should take pleasure in making Milton responsible for things he never said, is natural in view of his own expressed vulgar views of sacred things or pious men of

every age. To match this, we think somebody ought to make sport of the efforts made by the distinguished Adams, of Cambridge, and the younger Hill, of Washington, because they have not succeeded yet in getting the moon "in gear." Aside from a few real blemishes like these, chapter number three is a good one.

Brilliant Aurora. Mr. Geo. H. Peters, of Hartford, Conn., noticed a bright aurora June 3. It commenced at 9 o'clock P. M. and lasted thirty minutes. First a distinct arch was seen; at 9:15 streamers appeared in the northeast 35° high moving towards the west, gradually fading out and entirely disappearing in half an hour. There were no sun spots to be seen on that day or the following one.

Photographic Study of Stellar Spectra at Harvard College Observatory is shown in the second annual report by Professor E. C. Pickering of work done by the assistance of the Henry Draper Memorial. Two telescopes are constantly at work at the Observatory on photography every clear night. Four assistants take part in making the pictures, and five ladies are employed for measurements and reductions. The various investigations reported are:

1. Catalogue of spectra of bright stars.
2. Catalogue of spectra of faint stars.
3. Detailed study of the spectra of bright stars, and
4. Faint stellar spectra.

Two fine full-page plates show respectively the present location of the various photographic telescopes, and several cuts illustrating the work named above.

The mode of testing the sensitive plates is by exposing them to the polar sky, and the spectrum shown is that of the Pole-star. The star trails are very distinct in the illustration.

From the *Observatory* we learn that arrangements have been made for a redetermination of the longitude between Paris and Greenwich. Four observers, M. le Commandant Bassot and M. Defforges, from Paris, and Mr. Turner and Mr. Lewis, from Greenwich, are to take part in the work so as to have a double check on the personal equation.

An Astronomer's Summer Trip is the title of an article by Professor Young in the July number of Scribner's magazine. It will be remembered that Professor Young, of Princeton, with a party of observers, went to Europe to observe the total eclipse of the sun which occurred Aug. 19, 1887. The reason why Professor Young was especially interested in observing this eclipse was largely owing to a question that had been raised by Mr. Lockyear and others, as to the real existence of the so-called "reversing layer" of the sun's atmosphere which layer owes its scientific recognition mainly to an observation made by Professor Young himself during the eclipse of 1870. Of that observation he says:

"The slit of the spectroscope, attatched to a powerful telescope, was adjusted tangent to the sun's image at the precise point where the last ray would vanish under the advancing moon. A few moments before totality the spectrum still preserved in the main its familiar appearance except that certain lines usually only flickering and faintly bright at the sun's limb were now steady and conspicuous; this was specially true of the magnesium lines and the mysterious lines of the corona. The other countless dark lines remained hard and black. But the moment the sunlight vanished the dark lines instantly flashed into colored brightness, shone for two or three seconds, and then quickly faded away, leaving still visible only those which had been bright before totality. Of course, in the two or three seconds during which the phenomenon lasted, it was not possible to be quite sure that *all* the dark lines were thus reversed, and in this uncertainty lies the opportunity for varying interpretations of the phenomenon. The natural interpretation, in the light of what was then known, was that this bright line spectrum, which flashed out so beautifully, is due to a thin sheet of gaseous matter, overlying the luminous clouds which constitute the so-called 'photosphere,' and containing, in the vaporous form, all the substances which reveal themselves to us by the dark lines of the ordinary spectrum."

This much has been given that one of the important questions in the mind of astronomers for study might be understood and remembered by all our readers. It is already known to all that bad weather prevented all observation by this party, which must have been a great disappointment to them, in view of all the preparation, travel, waiting and anxiety that preceded the unpropitious day. But the account of Professor Young's visit to many of the leading

Observatories of Europe, with the illustrations and descriptions of the same, is delightful reading. The hospitality of these noted men, a glance at their work and their instruments, must have furnished some compensation for other losses however keenly felt.

M. Perrotin of France has noticed and traced four of the parallel canals of Mars recently, three of them starting from the "Seas" of the sonthern hemisphere, near the equator, and running northward up to the north polar ice-cap.

Topeka Astronomical Society. A. W. Waters, of Topeka, recently writes that an astronomical society is being formed in the above named place. It is in the contemplated plan to build an Observatory for the uses of the society and, possibly, to undertake original work. Mr. Waters is certainly interested in astronomical study and deserves encouragement and useful assistance.

We are pleased to learn with some degree of certainty, though not from official sources, that H. V. Egbert is now assistant in the Washburn Observatory at Madison, Wis. Astronomers generally know of his efficient astronomical work at Dudley Observatory, Albany, N. Y., during the seven years that he held a like position in that Observatory. It is a good thing for strong young men to come West.

The New Thirty-foot Dome, made by Messrs. Warner & Swasey, of Cleveland, for Carleton College Observatory is completed and in place, and is now taking its last coat of paint. It is constructed wholly of iron and steel, and its entire weight is 23,000 lbs. It is moved by a wire rope extending round the dome on the inside, and finally over two pulleys to another on the shaft of a wheel two feet in diameter, grooved in its circumference to receive a large rope that is placed within easy reach of the observer's hand. The movable part of the dome weighs over ten tons, and it is quickly set in motion by a vertical pull of 15 pounds. Its manipulation every way seems as perfect as human skill can make it. Messrs. Warner & Swasey have solved the question of making a dome for easy manipulation and apparent durablity.

Ciel et Terre for June republishes Professor Newcomb's address at the dedication of the observatory at Syracuse, N. Y. It appeared in the January and February numbers of this journal, and was translated into the French by E. Lagrange.

The June number of *Knowledge* contains a very *remarkable* review of Professor Langley's New Astronomy. American astronomers should read it.

The Royal Alfred Observatory. Director C. Meldrum favors us with a copy of his annual report for the year 1886. Meteorological, magnetic and solar observations constitute the body of the report. It is interesting to notice that sunspots were observed on 285 different days of the year, faculæ on 197, and that the number of photographs of the sun was 533, the largest number in any year since 1875.

The Moon and the Weather at Batavia (*Java*).—In the appendices to the volumes of observations at Batavia, Dr. van der Stok publishes studies of the influences of the moon on the meteorological elements. He finds an appreciable effect on the cloudiness. The cloudiness there increases with the increase of the distance of the moon above the horizon, reaching its maximum at the superior meridian transit and its minimum at the inferior one. Thus the influence of the moon appears to be felt when she is below the horizon, which excludes the hypothesis of its being the result of direct radiation. There is also greater cloudiness at full than at new moon. In each case the extreme difference averages about 5 per cent. The temperature, too, proves to be somewhat higher when the moon is below than when she is above the horizon, and in October and November the difference amounts to almost one degree Fahrenheit. The lunar effect is more marked in the west than in the east monsoon.

Batavia is especially suited to the study of the atmospheric tides, as irregular barometric disturbances are unknown there. The existence of such tides is more and more completely proved as the number of observations increases; but the tides are small, though not so small as the mechanical theory of tides requires.

Dr. H. C. Wilson, of Carleton College Observatory, has been employed to deliver two lectures on astronomical themes during the first days of this month at the summer school of Mahtomedi Chautauqua Assembly. His themes will be illustrated, by the aid of the lantern, with pictures prepared for the occasion, some of them being drawings of solar prominences made at the telescope during the last month.

Errata. Mr. Monck of Dublin, Ireland, calls our attention to the following errors in our last issue:

Page 236, line 15 from end, for "confined" read "comprised."

Page 237, first line of table, for "Leebyer" read "Seeleger."

Same page, first line of table, for 9.5 read 6.5.

In the note on the dissipation of comets for "De Vico" read "Di Vico."

BOOK NOTICES.

"The New Astronomy" is the title of an important book, written by Professor S. P. Langley, secretary of the Smithsonian Institution, at Washington, and recently published by Messrs. Ticknor & Co., Boston, Mass. In the June number of this journal a notice of this book appeared by another who spoke well of its merits but rather too briefly to draw deserved attention to the character and value of its contents. This is the purpose of a second and a fuller notice.

The first chapter of The New Astronomy is a study of the spots of the sun. The author begins by noticing the difference between the instruments and apparatus used by the ancients in determining the places of the heavenly bodies, and those found in the modern observatory like that of Greenwich or Washington. The contrast is surprisingly great in favor of the modern instruments of precision, in power, utility and adaptation. The author says the chief object of the astronomer, in all the past until recent years, has been to learn exactly *where* the heavenly bodies are on the celestial sphere at any given time. The further question

now is, What *are* they? What is their constitution? What is their relation to ourselves? When applied to the sun, moon and stars, these are the questions of the New Astronomy, sometimes called solar physics or celestial physics.

A picture of the sun's corona and chromosphere, with illustrations of distance, introduces the reader to some fine photographs of the surface of the sun as a whole, as seen through the telescope and photographed in 1870. Though these pictures are small they are useful in giving the general reader a correct idea of what a good telescope reveals of the surface of the sun to the eye of an experienced observer. The well-known picture of Nasmyth's "willow leaves," with Sir John Herschel's explanation of their nature, stands in striking contrast with those beautiful and inimitable drawings of sun spots which were observed by the author in the months of March and December of 1873. The minutiæ of detail that these drawings show in easy relief is most wonderful when the reader remembers that such parts of a sun spot in its active stage are changing so constantly and rapidly as to greatly tax the skilful artist to catch them and bring out a harmonious whole; yet this very thing is necessary to furnish all this abundant data for philosophic study of the later phases of solar physics. The author leans toward Faye's theory of the sun spots in regard to vertical circulation, and cautiously says that his "cyclone theory" has some evidence for its support. The second chapter deals with the sun's surroundings. A large number of views of the solar corona, on occasions of the total eclipses of the sun since 1869, find place in a connected account of the more important observations of this strange phenomenon for the last ten years. What the corona is, or how it is to be explained, Professor Langley frankly says the most learned do not know. The evidence whether it is a gas or not is conflicting, although the green coronal line of the spectroscope seems to say plainly, that it contains an unknown gas of extreme tenuity. It is possible to think of the corona, especially in its outer parts, as made up of minute dust particles like those of the meteoric train, and it is also possible to believe that it is *partly* a phenomenon caused by the diffraction of light, as argued so well by Professor Hastings after his observations of it at Caroline

Island in 1883. Professor Langley, however, does not think that this latter theory is sufficient to explain the corona as a whole, for he does not believe it to be a "phantasm" dependent only on the changes which the presence of the moon may bring, but rather an appendage belonging to the sun and therefore having a real existence.

The author next describes the chromospere of the sun, that envelope rising here and there into prominences of a rose and scarlet color, invisible in the telescope, except at a total eclipse, but always visible through the spectroscope. This thin envelope appears to be formed by heated gas issuing through the pores of the entire visible surface of the sun, and, overlapping it, makes a literal lake of fire, whose waves of flame heave and toss like those of the fiercest conflagration the imagination can picture. These flames are evidently "connected with that uprush of heated matter from the sun's interior forming part of the circulation which maintains both the temperature at its surface and that radiation on which all terrestrial life depends." They are the signs of what is going on beneath the surface of the sun, but more than this The New Astronomy has little to say.

In the third chapter, the sun's energy, the author enters on his own special field of labor and original research for years, and to this part of his studies we wish to give special attention, and hence reserve what we have to say till our next issue.

(TO BE CONTINUED.)

An Elementary Treatise on the Integral and the Differential Calculus. With Numerous Examples. By EDWARD A. BOWSER, LL. D., Professor of Mathematics and Engineering in Rutgers College. Ninth Edition. New York: D. Van Nostrand, 23 Murray street, 1887. 12mo., cloth, pp. 305. Price $2.25.

By courtesy of the publisher, we have recently, for the first time, had the pleasure of examining the series of Mathematics published since 1880 by Professor Bowser of Rutgers College, New Brunswick, N. J. The calculus we have read with unusual interest, because we think it so well adapted to the class room. The statement of principle is clear and exact, without needless verbiage. As an example of this we quote the author's remarks limiting the meaning of the terms infinite and infinitesmal. He says, "An infinite is not

the largest possible quantity, nor is an infinitesimal the smallest; there would in this case be but *one* infinite or infinitesimal. Infinities may differ from each other and from a quantity that transcends every assignable quantity, that is, from absolute infinity. So may infinitesimals differ from each other, and from absolute zero." This is what every teacher of the calculus knows, and is often called upon to explain; but how rarely do the text books specialize such points that are all important for the beginner to give him right notions, which he may get for himself as he starts in this new and difficult field of study. We are glad to see that the author has adopted the method of *infinitesimals* in explaining the fundamental principles of the subject, for it is certainly to be preferred to the method of *limits*. The later chapter on *limits* makes the work complete so far as theories of both methods are concerned. This book covers the usual ground of the latest and best books on this branch, and it is especially commended for its numerous examples, its illustrations and its applications. Teachers who desire a large number of examples for students to solve will be gratified with what is contained in this book, and the student who masters them all will certainly not lack a good knowledge of the elements of the Calculus.

We have also received, by the same author, An Elementary Treatise on Hydromechanics, An Elementary Treatise on Analytic Mechanics, and An Elementary Treatise on Analytic Geometry. Notices of these books will appear in the next number of this journal.